Superpave
IMPLEMENTATION UPDATE
WINTER 2002-2003

CONTENTS

1
TECHNICAL NEWS

◆ ◆ ◆

4
RESEARCH NEWS

FHWA Launches New Testing Program for Modified Asphalts

Task Team Refines Angle Validation Measurement

Mixture and Aggregate ETG Update

Binder ETG Update

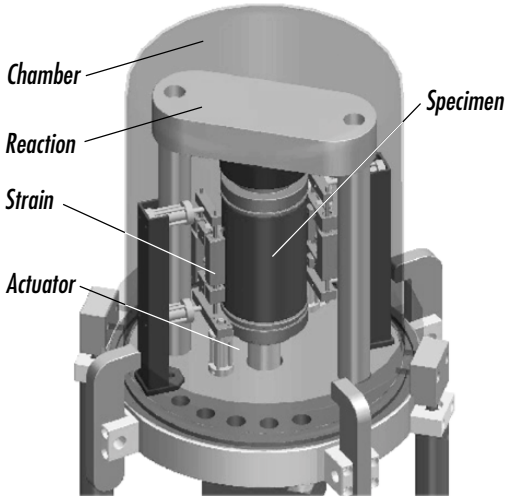
NCHRP Project Update

U.S. Department of Transportation
Federal Highway Administration

First Simple Performance Testers Delivered

This summer, Interlaken Technology Corp. (Eden Prairie, MN) and Shedworks Inc. (College Station, TX) delivered the first models of a new device that can perform three simple performance tests designed to give contractors and road-building agencies extra confidence in the rut- and crack-resistance of mixes that meet volumetric mix design criteria. Production of the equipment is an important milestone in the NCHRP/FHWA-funded research program to develop a simple performance test for the Superpave system. The device is designed to conduct three tests that were identified under NCHRP Program 9-19:

- Creep Test (tests rut-resistance)
- Repeated Load Test (tests rut-resistance)
- Complex Modulus, Frequency Sweep Test (tests rut- and fatigue crack-resistance)



The equipment was delivered to Advanced Asphalt Technology (AAT) in Sterling, VA and FHWA's laboratory in McLean, VA, where it is being evaluated through National Cooperative Highway Research Program (NCHRP) Project 9-29. AAT's

Continued on next page

FHWA's Mobile Asphalt Laboratories Support Superpave Research, Deliver On-Site Technical Support

Equipped with Superpave test equipment and staffed by technicians with expert knowledge of the Superpave testing protocols, the FHWA's Mobile Asphalt Mixture and Binder Laboratories helped to introduce Superpave to many States in its early years, and later helped to do final development on changes to the systems and tests.

In recent years, the mixture laboratory's principal mission has been to refine new procedures by "shadow testing" (duplicating) mix design tests conducted by contractors and State highway agencies in their own laboratories. The binder laboratory continues to support State training and testing. In addition, the mobile laboratories validate the results from selected National Cooperative Highway Research Program (NCHRP) projects quickly and efficiently. The mobile laboratory staff and equipment have been used to refine and validate more than 15 new and modified pieces of mixture test equipment and procedures.

The FHWA mobile asphalt laboratories ("trailers") have visited Arizona three times—

Continued on next page

PERFORMANCE TESTERS / from page 1

deadline for reporting the results of the equipment tests is April 2003.

"The result of our project will be a detailed purchase specification that agencies can use to select test equipment," said Ray Bonaquist, AAT's Chief Operating Officer.

AAT also developed the "first article specification" for the prototype equipment. The equipment was developed based on draft test protocols produced by Arizona State University and the University of Maryland under NCHRP Project 9-19. AAT met with potential equipment users to determine what features are most important to user-friendliness.

"The equipment is designed to be used by technicians, not engineers or researchers. We want something that individuals who would be involved in normal mix designs for a hot mix contractor can use," Bonaquist said.

Affordability also is very important. Initial costs will be in the $40,000 - $50,000 range, Bonaquist said. One of the manufacturers already is marketing the equipment.

For more information, contact John D'Angelo. Phone (202) 366-0121; Fax (202) 366-7909; *john.d'angelo@fhwa.dot. gov*

Shedworks Simple Performance Test Equipment

FHWA'S LABORATORIES/ from page 1

in 1996, 1999, and 2001. "The trailers are a great resource that have enabled us to gather data we wouldn't otherwise have," said Dr. Julie Nodes, Arizona Department of Transportation (AZDOT) Pavement Materials Testing Engineer. "The trailers made it possible for us to illustrate that two laboratories can achieve parallel test results. This can be a big issue for us when contractors dispute the State laboratory test results and do not believe it is possible for two laboratories to achieve comparable results. They also helped us to learn how to use some of the different kinds of gyratories, and to get training on a model of gyratory we had just purchased. It was quite valuable to get training from people who were experienced in running it." The binder laboratory has conducted back-up testing for AZDOT on several occasions when the State lacked equipment to perform certain tests, Nodes added.

"When they are not physically here, I still use the mobile laboratory staff as a resource," Nodes said. "If we have a problem, I pick up the phone and call John D'Angelo or Chuck Paugh to ask if they've seen something similar. Their expertise is a great and continuing value to us."

"It was very beneficial to have the trailer here," agreed Gary Mayes, Michigan Department of Transportation Supervising Engineer. "We were able to send some new employees to get great hands-on experience and training in testing. When we were first starting to do Superpave, we got some initial data on how a typical Michigan DOT project would have been evaluated under a percent within limits (PWL) specification. We certainly appreciated them coming out."

Mobile Asphalt Mixture Laboratory Accomplishments

Activities and accomplishments of the mobile asphalt mixture laboratory include:

◆ **Field testing for performance-related specifications:** The mobile asphalt mixture laboratory is providing most of the field data that will be used to refine and validate the performance-prediction models that will be the basis for performance-related specifications (PRS) for hot mix asphalt (HMA). Beta testing and validation of the PRS for HMA are currently being conducted by Fugro-BRE, Inc. under National Cooperative Highway Research Program (NCHRP) Project 9-22. (See *NCHRP Project Update,* p. 6.)

◆ **Specification and procedure for calibrating gyratory compactor:** The mobile asphalt mixture laboratory collaborated with the FHWA asphalt research laboratory to develop a detailed research plan and conduct extensive testing to develop a specification and procedure to internally calibrate the angle of gyration for the Superpave gyratory compactor. A

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new measurement device called the Dynamic Angle Validator (DAV) was developed, along with new specifications. (See *Task Team Refines Angle Measurement Device,* p. 4.)

◆ **Evaluation procedure for new gyratory compactors:** Based on comparison data developed in the mobile laboratory, an AASHTO procedure (PP35) was developed to evaluate new gyratory compactors brought to the marketplace.

◆ **Procedure to compare gyratory compactors:** Based on field testing data developed in the mobile laboratory, a procedure was developed and submitted to AASHTO to compare gyratory compactors used for design and QC testing in the field.

◆ **Initial mix design information for 30 States:** The mobile asphalt mixture laboratory assisted 30 States in developing initial Superpave mix designs using locally available aggregates. This was instrumental in overcoming early uncertainty regarding the feasibility of using the Superpave system.

◆ **Technical assistance with density and permeability problems:** When the Florida Department of Transportation experienced density and permeability problems with their early Superpave mixes, the mobile asphalt mixture laboratory staff developed designs for a 9.5 mm mix using local aggregates. This enabled the State to develop a finer-graded mix that was easier to compact, and could be used as a high-density surface mix.

◆ **Field mix verification procedure for Superpave mixes:** Based on procedures and data developed in the mobile laboratory, an AASHTO-formatted procedure was developed for construction mix verification.

◆ **Field QC testing for WesTrack Project:** The mobile asphalt mixture laboratory developed mix designs and performed field QC testing for the WesTrack project, which examined how deviations in materials and construction properties (such as asphalt content and degree of compaction) affect the eventual pavement performance, and provided early field verification of the Superpave mix design method. The WesTrack Pavement Test Facility in Reno, Nevada, which was constructed by the Nevada Automotive Test Center, was used for this project.

The mobile asphalt mixture laboratory has provided support to various other research- and implementation-related tasks. Examples include:

- Revision of calibration procedures for the ignition oven to compensate for dust in the mix. Hydrated lime also affects the calibration;
- Evaluation of new equipment and procedures for determining the bulk specific gravity of mix and aggregate;
- Evaluation of the bulk specific gravity procedure for compacted specimens to reduce variability and improve accuracy. The preliminary laboratory experiment has been completed, and data analysis is under way;
- Evaluations of the changes to the Superpave system that are recommended by NCHRP the Lead States and by NCHRP.

Mobile Asphalt Binder Laboratory Accomplishments

◆ **Evaluation and refinement of the Dynamic Shear Rheometer (DSR):** The mobile asphalt binder laboratory staff performed experiments to refine the test procedures for the DSR to improve repeatability and ease of use by technicians. These recommendations were reviewed and accepted by AASHTO.

◆ **Evaluation and refinement of Bending Beam Rheometer (BBR):** The mobile asphalt binder laboratory staff performed experiments to refine the test procedures for the BBR and to improve repeatability and ease of use by technicians. They also investigated problems of repeatability between manufacturers and recommended equipment specification changes. These recommendations were reviewed and accepted by AASHTO.

◆ **Development of equipment and procedures for the Direct Tension Test (DTT):** The mobile asphalt binder laboratory staff worked closely with industry to develop the Direct Tension Test. They evaluated prototype equipment and developed new test procedures.

◆ **Training:** Laboratory technicians and engineers from more than 20 States received training in use of binder test equipment through the mobile asphalt binder laboratory program.

◆ **Evaluation of Modified Rolling Thin Film Oven Test (RTFOT) procedure:** The mobile asphalt binder laboratory staff has completed a detailed review of the proposed changes to the RTFOT procedure using additional binder. The proposed procedure could not be validated and a recommendation was made not to use the procedure.

◆ **Evaluation of the high temperature test procedure recommended under the NCHRP 9-10 Project:** The mobile asphalt binder laboratory staff is conducting a detailed study to evaluate the new high-temperature test procedure recommended by the NCHRP 9-10 research team. The study includes evaluation of test precision and evaluation of surrogate criteria. Specification criteria are being developed based on field performance.

◆ **Development of MP1A specifications:** The mobile asphalt binder laboratory staff participated in development of a new AASHTO provisional specification that includes both modified and non-modified materials. Development involved extensive testing of materials from field test sites. The new specification combines test results from the DTT and the BBR.

◆ **Testing to refine TP 48 for the rotational viscometer:** The mobile asphalt binder laboratory staff undertook a study at the request of the AASHTO Subcommittee on Materials (SOM) to evaluate whether the temperature control (+/- 0.1° C) specified in the original specification is needed for TP 48 "rotational viscometer." The study indicated that temperature control +/- 1.0° C is sufficient for TP 48 and the AASHTO procedure TP 48 was modified to reflect this change.

For more information contact John D'Angelo. Phone (202) 366-0121; Fax (202) 366-7909; *john.d'angelo@fhwa.dot.gov*

RESEARCH NEWS

Pooled Fund Participants Sought

FHWA Launches New Testing Program for Modified Asphalts

State and industry asphalt experts met with FHWA staff Dec. 5 and 6 to launch a new modified asphalt testing program at the FHWA's Turner-Fairbank Highway Research Center's (TFHRC's) Pavement Testing Facility. The experts gathered to cut the ribbon to mark the start of a three-year program to test 12 newly constructed asphalt pavement sections with two Accelerated Loading Facility machines.

The new modified asphalt testing program is a key step in a national effort to expand Superpave specifications to cover asphalt binders modified with polymer and other additives. State highway agencies are increasing the use of the modifiers to provide more

A very early Washington snowstorm didn't stop 17 State and industry asphalt experts from gathering at the FHWA Turner-Fairbank Highway Research Center's (TFHRC's) Pavement Testing Facility Dec. 5 and 6 for a ribbon-cutting ceremony to mark the start of a new three-year modified asphalt testing program. The new program is a key step in a national effort to expand Superpave specifications to cover asphalt binders modified with polymer and other additives. State highway agencies are increasing the use of the modifiers to provide more resistance to rutting, fatigue cracking, and low-temperature cracking.

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Research studies have identified shortcomings in the Superpave binder specification's ability to characterize the performance of modified asphalt binders. The modifiers, which include polymers and other additives, are principally used in areas of high traffic volume, heavy loading, and extreme climatic conditions. Many appear to be quite effective. Modifier usage varies widely among State highway agencies, but it is increasing steadily nationwide. Currently modifiers are being employed in about 8 percent of the hot mix asphalt (HMA) being placed.

In 1996, following an FHWA report on needed improvements to the Superpave specification, the National Cooperative Highway Research Program (NCHRP) initiated Project 9-10, "Superpave Protocols for Modified Asphalt Binders." In August 2001, this $1 million study, conducted by The Asphalt Institute, generated several recommended enhancements to the Superpave binder specification [American Association of State Highway and Transportation Officials (AASHTO) Standard MP1]. Prior to adoption by AASHTO, these recommendations are being validated and reviewed by the Transportation Research Board's (TRB's) Superpave Binder Expert Task Group.

The FHWA, with funding from NCHRP, has completed an extensive laboratory evaluation of the proposed protocols for modified binders. The new modified asphalt testing program will follow up on the laboratory studies with full-scale accelerated performance testing using the FHWA Pavement Testing Facility. The TRB Superpave Committee recommended that FHWA fund the new modified asphalt testing program through a pooled fund. (In pooled fund research, participating States agree to allow a portion of their federal-aid research funding to be used for the designated research.) The FHWA is continuing to solicit State participation in the new program.

Research Objectives: The primary objectives of the new modified asphalt testing program are to evaluate and validate the proposed changes in the Superpave binder specification, and to provide AASHTO with a binder purchase specification that is "blind" to the type of modification.

To achieve this objective, different modified materials have been placed in pavement test sections of various thicknesses. As with prior full-scale pavement research studies, the test sections will be used to investigate other research topics, including:

- The Superpave Simple Performance Test;
- Mechanistically Designed Pavements (*2002 Pavement Design Guide*);
- Falling Weight Deflectometers (FWDs); and
- Crumb Rubber Modified (CRM) Asphalt Pavements.

For more information about the new modified asphalt testing program, contact Dr. Terry Mitchell. Phone (202) 493-3147; Fax (202) 493-3161; Terry.Mitchell@fhwa.dot.gov; or Thomas Harman; Phone (202) 493-3072; Fax (202) 493-3161; Tom.Harman@fhwa.dot.gov.

Task Team Refines Angle Validation Measurement

Variability caused by differences in the calibration of Superpave gyratory compactors is a significant problem. A Dynamic Angle Validation (DAV) Task Team is conducting ruggedness studies of a new device for measurement of the dynamic internal gyration angle.

Tests on the new device, known as the Superpave Dynamic Angle Validator (DAV), are being conducted at multiple laboratories in order to identify the critical operational parameters. When the ruggedness studies are completed, a "round robin" study will be conducted. Results will be used to develop a precision and bias statement for use in any subsequent ASTM or AASHTO test specifications.

Organizations participating in the Task Team and the laboratory studies include the University of Arkansas, the FHWA, APAC material services, the National Center for Asphalt Technology (NCAT), the Florida Department of Transportation, The Asphalt Institute, Troxler Inc., and Pine Instruments. The group includes representatives of both an ASTM subcommittee, and the TRB Superpave Mixture and Aggregate Expert Task Group (ETG). Several members belong to both sponsoring groups.

The Task Group has recommended future study of the relationship between internal angle and mixture stiffness, and is developing parameters for a relatively comprehensive research study.

Previous studies by the Task Team and the FHWA have revealed that an internal gyration angle of 1.16 ± 0.02,° measured internally in a dynamic condition, is more appropriate than 1.25 ± 0.02,° measured externally in a static condition.

AASHTO has adopted provisional standards for the operation of the DAV and inclusion in the calibration of the gyratory compactor.

—Kevin D. Hall, University of Arkansas

Mixture and Aggregate ETG Update

Highlights of the TRB Superpave Mixture and Aggregate Expert Task Group (ETG) February 2002 meeting are summarized below.

◆ **4.75 mm Superpave Mixture:** At previous meetings, the ETG had identified a need for a 4.75 mm Superpave mix, for use as a leveling, or thin-surfacing, mix. A Task Team led by Jimmy Brumfield (Mississippi DOT) met and developed: (1) modifications to AASHTO MP-2 *(Standard Specifica-*

Gradation Classification

PCS Control Point for Mixture Nominal Maximum Aggregate Size (% Passing)

Nominal Maximum Aggregate Size	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm
Primary Control Sieve	9.5 mm	4.75 mm	4.75 mm	2.36 mm	2.36 mm
PCS Control Point	47	40	47	39	47

tion for Superpave Volumetric Mix Design); and (2) documentation of the complete rationale for the development of these changes. These changes were reviewed in detail by the ETG, which was in full agreement to adopt them. They were forwarded to the SOM, which approved provisional adoption in August 2002.

◆ **Aggregate Gradation Optimization:** As a follow-up to previous work conducted by the ETG on the Bailey Method of aggregate optimization, Gerry Huber developed a draft TRB circular titled, *Bailey Method for Gradation Selection in HMA Mix Design,* which has been forwarded to TRB Committee A2D02 for their consideration.

Because other aggregate blending methods in addition to the Bailey Method currently are in use, Gerry Huber (The Asphalt Institute) was asked to develop a Problem Statement for a synthesis report on various aggregate blending methods for HMA, for consideration by TRB.

◆ **Elimination of the Restricted Zone:** Based on the findings of *NCHRP Project 09-14 Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification,* the ETG recommended to the SOM that all references to the restricted zone be deleted from AASHTO MP-2 *(Standard Specification for Superpave Volumetric Mix Design)* and PP-28 *(Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt).* The SOM approved this recommendation at its August 2002 meeting.

In addition, the ETG approved definitions for coarse and fine mixes, which subsequently were forwarded to the SOM and approved. (See *"Gradation Classification"* table, above.)

◆ **AASHTO Standards Options:** Based on an analysis of AASHTO Materials Reference Laboratory (AMRL) data compiled from recent AASHTO T-209 *(Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures)* proficiency samples, the ETG recommended the following changes to the SOM:

- Section 7.2: Reword table defining minimum sample sizes to reflect current Superpave terminology (nominal maximum aggregate size);
- Section 9.4: Delete option that allows sample to be agitated manually.

The SOM adopted these recommendations.

—James A. Musselman, Florida Department of Transportation (Chair)

Binder ETG Update

Modified binders continue to be a major focus of activity for the Superpave Binder Expert Task Group (ETG). As use of polymers increases, the need for resolution of issues related to modified pavement systems becomes more urgent. The ETG has set 2005 as a target date for resolution of these problems.

◆ **Changes to the Dynamic Shear Rheometer (DSR) specification:** Dave Anderson (Pennsylvania State University) and Suzanne Logan (Koch Pavement Solutions) are preparing a draft of proposed revisions to the DSR specification for the ETG to review. Some issues include: distinctions between calibration and verification; elimination of machine specifications that cannot be checked in the field; issues concerning condition of the plates and plate cleaning; temperature control; temperature equilibrium in the sample; and mounting procedures. The ETG recommended that these changes be incorporated into AASHTO as an appendix, rather than included in a new specification.

◆ **Refinement of the Direct Tension Test (DTT):** The ETG needs to evaluate how different test procedures affect the critical cracking temperature. Several iterations of different test procedures will be required in order to develop a practical test procedure that the asphalt industry will accept. A round robin that includes participation from three different laboratories will be conducted to evaluate critical cracking temperature and the DTT test protocol.

◆ **Modified German Rolling Flask (MGRF)—Development of Test Method:** This method provides a greater amount of material for further analysis than the Rolling Thin Film Oven test. The ETG recommended that the FHWA continue to evaluate the MGRF method. The existing requirements for rotational speed and temperature were found to be important. The FHWA will continue the experiment and include an SBS Di-block polymer. They will also work with existing manufacturers to develop off-the-shelf equipment satisfying the existing MGRF standard.

◆ **Fatigue Study Group:** The Fatigue Study Group, which includes representatives of Ergon, Idaho Asphalt, Koch, Citgo, Kraton Polymers, and The Asphalt Institute, is focusing on the refinement of the fatigue

parameter (G*sindelta). The present parameter does not define the true performance characteristics of modified binders. The ongoing investigations are considering approaches taken from mixture work in the Indirect Tension Test (IDT), and applying them to the Direct Tension Tester. The dissipated creep strain energy, C and S parameters based on pseudo-strain and damage parameters, can be obtained from the DTT.

◆ **Laboratory Mixing and Compaction Temperatures:** A proposed Specification for Laboratory Mixing and Compaction Temperatures was presented by Hussein Bahia. This method is centered on the concept of "low-shear viscosity." The ETG felt that this procedure is a step forward and that validation work should proceed. Hussain Bahia (University of Wisconsin) will head a task force comprised of representatives from of the Florida, Georgia, Pennsylvania, and New Mexico state transportation departments.

—Cameron C. Petersen, Utah Department of Transportation (Chair)

For more information, contact John D'Angelo. Phone (202) 366-0121; Fax (202) 366-7909; *john.d'angelo@fhwa.dot.gov*

NCHRP Project Update

Here is an update of key Superpave-related National Cooperative Highway Research Program (NCHRP) projects recently completed, currently under way, or anticipated.

◆ **NCHRP 9-9(1) Verification of Gyration Level in the N-design Table:** The purpose of this study is to verify through a series of field project evaluations that the gyration levels in the N_{design} table in AASHTO PP28 are correct for the stated project traffic levels. Fieldwork continues for monitoring densification of pavement on 40 field projects, under traffic and in-service performance, for up to two years. These results will be used in conjunction with data from the National Center for Asphalt Technology (NCAT) test track experiment and other controlled pavement performance tests for the verification analysis. This study is being conducted by the NCAT at Auburn University, and is scheduled for completion in 2003.

◆ **NCHRP 9-19 Task C—Identification of a Simple Performance Test:** The research team conducted a comprehensive laboratory testing program to statistically correlate the actual performance of HMA materials from the MnRoad, WesTrack, and FHWA Accelerated Loading Facility (ALF) experiments with the measured responses of specimens prepared from original materials for 33 promising test method-test parameter combinations.

Based on the results of this testing program, the research team recommends three test-parameter combinations for further field validation as a simple performance test for permanent deformation: (1) the dynamic modulus term, E*/sinf, determined from the triaxial dynamic modulus test; (2) the flow time, $F_{T,}$ determined from the triaxial static creep test; and (3) the flow number, $F_{N,}$ determined from the triaxial repeated load test. All combinations exhibit a coefficient of determination, r^2, of 0.9 or greater for the combined correlation of the laboratory test results with performance in the MnRoad, WesTrack, and FHWA ALF experiments. Testing is now under way, with materials from a wide range of LTPP SPS field sections as well as accelerated pavement test projects, to identify which of the three candidates provides the best correlation with actual field performance.

◆ **NCHRP 9-22 Beta Testing and Validation of HMA Performance-Related Specification:** The key objectives of this project are to evaluate and refine the HMA performance-related specification (PRS) and supporting software developed through the WesTrack project in a series of field trials, and to efficiently integrate the HMA performance models from the *2002 Pavement Design Guide* with the HMA PRS software. The HMA PRS

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FEDERAL HIGHWAY ADMINISTRATOR

Mary Peters, *Administrator*
400 Seventh Street, SW
Washington, DC 20590

OFFICE OF PAVEMENT TECHNOLOGY

Tommy Beatty, *Director*

John D'Angelo,
Asphalt Team Leader
202-366-0121

OFFICE OF INFRASTRUCTURE RESEARCH & DEVELOPMENT

T. Paul Teng, *Director*
Thomas Harman,
Asphalt Pavement Team Leader
202-493-3972

EDITOR

Karen Haas Martin
Ph: 301-963-5708
Fax: 301-963-5709
editorsink@starpower.net

software program (HMASpec), produced in the FHWA WesTrack project (NCHRP Project 9-20), has been beta-tested, and a revised release 1.1 prepared. In 2001, extensive QC/QA results were collected on field construction projects in Arizona, Florida, Colorado, Illinois, and Maryland for evaluation of HMASpec 1.1 as a "shadow specification."

A plan has been approved for the next phase of the project, to develop and test the next version of HMASpec (now designated version 2.0). Version 2.0 will incorporate the requisite PRS elements (along with the original WesTrack performance models) into the *2002 Pavement Design Guide* software program. This project is being performed by Fugro-BRE Inc. and is scheduled for completion in 2004.

◆ **NCHRP 9-25 Requirements for Voids in Mineral Aggregate for Superpave Mixtures:** The objective of this research is to develop recommended mix design criteria for VMA (voids in mineral aggregates), VFA (voids filled with asphalt), or calculated binder film thicknesses, as appropriate, to ensure adequate HMA durability and resistance to permanent deformation and fatigue cracking for coarse and fine, dense-graded mixes in the context of the Superpave mix design method. This work is being conducted by Advanced Asphalt Technologies and is being coordinated with work under NCHRP Project 9-31 (see below). A Phase I interim report is available for loan from NCHRP. The project is scheduled for completion in October 2003.

◆ **NCHRP 9-29 Simple Performance Tester for Superpave Mix Design:** Candidate devices are currently being validated. The project is being conducted by Advanced Asphalt Technologies LLC and is scheduled for completion in 2003. (See p. 1.)

◆ **NCHRP 9-31 Air Void Requirements for Superpave Mix Design:** The contractor, Advanced Asphalt Technologies, currently is evaluating how variation in the range of design air void contents currently in use by State highway agencies influences HMA durability, performance, and compaction. A Phase I interim report is available for loan from NCHRP. The project is scheduled for completion in October 2003. The objective of the project is to develop recommended ranges for design air void content. These ranges are to be validated in the field, as a subsequent research project.

◆ **NCHRP 9-33 A Mix Design Manual for Hot Mix Asphalt:** A project statement (request for proposals) is expected soon for a new NCHRP project to develop a practical procedure and a manual for designing hot mix asphalt (HMA) mixes that incorporate the simple performance test as well as the material tests and performance models in the *2002 Pavement Design Guide*. It is hoped that these models also could be used in performance-related specifications. This would result in the same model platform for mix design, structural design and specification control.

◆ **NCHRP 9-34 Improved Conditioning Procedure for Predicting the Moisture Susceptibility of HMA Pavements:** The objective of this research is to develop improved conditioning procedures, based on the environmental conditioning system for evaluating the moisture susceptibility of compacted HMA, in combination with the simple performance test being validated in NCHRP Project 9-19. This two-year project was awarded to Pennsylvania Transportation Institute in March 2002.

NCHRP conducts research in acute problem areas that affect highway planning, design, construction, operation, and maintenance nationwide. NCHRP is administered by the Transportation Research Board (TRB) and sponsored and supported by the AASHTO members (State departments of transportation), in cooperation with the Federal Highway Administration.

—Edward T. Harrigan, NCHRP

For more information, contact Edward T. Harrigan at NCHRP. Phone (202) 334-3232; *eharriga@nas.edu.*

U.S Department
of Transportation

Federal Highway Administration

400 Seventh St., S.W.
Washington, DC 20590

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